

Additional file 1

Summary of model parameters and equations

Parameters and equations are based on information presented in Mount et al. [1] unless otherwise specified.

Fecundity (F ; eggs/engorged female)

Depend on the mean temperature (T ; 12°C-32°C) during preoviposition

$$F = -7487.5 + 790 \cdot T - 14.5 \cdot T^2; \text{ for ticks obtaining blood meal from cattle}$$

$$F = (-565.56 + 59.67 \cdot T - 1.10 \cdot T^2) \times 0.8227; \text{ for ticks obtaining blood meal from white-tailed deer [2]}$$

Eggs

Base survival rates (S_E , under optimal weather conditions) in three different types of pasture

CDW (cumulative degree-weeks) ≥ 36

DT (minimum developmental threshold temperature) = 15

$$1-4 \text{ weeks old, } S_{E1} = \begin{cases} 0.964264 & (\text{improved dense pasture}) \\ 0.9362846 & (\text{unimproved light pasture}) \\ 0.888922 & (\text{improved light}) \end{cases}$$

$$> 4 \text{ weeks old, } S_{E2} = \begin{cases} 0.8344503 & (\text{improved dense pasture}) \\ 0.8015637 & (\text{unimproved light pasture}) \\ 0.7148943 & (\text{improved light}) \end{cases}$$

Note that for habitat-specific tick survival parameters, we have retained the original habitat names in Mount et al. [1]: “improved dense pasture,” “unimproved light pasture,” and “improved light,” which they used to refer to good, fair, and poor habitats, respectively, relative to survival of off-host ticks. These parameter values were based on maximum survival times reported in eight independent studies conducted in a variety of habitats (see page 225 in Mount et al. [1]). In the text describing our study, we have used the names “mesquite savanna,” “mixed-brush savanna,” and “open un-canopied grassland” to refer to good, fair, and poor habitats, respectively, relative to survival of off-host ticks.

Survival rate effects (SRE) for the temperature (T), saturation deficit (SD), and precipitation index (PI) (the following equation, SRE_{E1} will be used for 1-4 weeks old eggs, 1-6 weeks old larvae, and 1-4 weeks engorged females, and SRE_{old} will be used for > 4 weeks old eggs, > 6 weeks old larvae, and > 4 weeks engorged female as well)

$$1-4 \text{ weeks old, } SRE_{young} = (-0.00097222 \cdot T^2 + 0.03111111 \cdot T + 0.75111111) \times (-0.00123643 \cdot SD^2 + 0.01456543 \cdot SD + 0.95708835) \times (-0.00060557 \cdot PI^2 + 0.0159513 \cdot PI + 0.89479707)$$

$$> 4 \text{ weeks old, } SRE_{old} = (-0.00114583 \cdot T^2 + 0.036250 \cdot T + 0.71333333) \times (-0.00141020 \cdot SD^2 + 0.01827455 \cdot SD + 0.94021589) \times (-0.00074267 \cdot PI^2 + 0.0194957 \cdot PI + 0.87183511)$$

Free-living (host seeking) larvae

Base survival rates (S_{FL} , under optimal weather conditions) in three different types of pasture

$$1-6 \text{ weeks old, } S_{FL1} = \begin{cases} 0.9539088 & (\text{improved dense pasture}) \\ 0.9342157 & (\text{unimproved light pasture}) \\ 0.9001101 & (\text{improved light}) \end{cases}$$

$$> 6 \text{ weeks old, } S_{FL2} = \begin{cases} 0.9154279 & (\text{improved dense pasture}) \\ 0.8982628 & (\text{unimproved light pasture}) \\ 0.8516867 & (\text{improved light}) \end{cases}$$

Survival rate effects (SRE) for the temperature (T), saturation deficit (SD), and precipitation index (PI)

$$1-6 \text{ weeks old, } SRE_{young} = (-0.00097222 \cdot T^2 + 0.03111111 \cdot T + 0.75111111) \times (-0.00123643 \cdot SD^2 + 0.01456543 \cdot SD + 0.95708835) \times (-0.00060557 \cdot PI^2 + 0.0159513 \cdot PI + 0.89479707)$$

$$> 6 \text{ weeks old, } SRE_{old} = (-0.00114583 \cdot T^2 + 0.036250 \cdot T + 0.71333333) \times (-0.00141020 \cdot SD^2 + 0.01827455 \cdot SD + 0.94021589) \times (-0.00074267 \cdot PI^2 + 0.0194957 \cdot PI + 0.87183511)$$

Host-finding rate

Relative rates of host-seeking activity of off-host larvae (HFR, the proportion of off-host larvae that potentially could encounter and attach to a host)

$$HFR = -0.008 \times T^2 + 0.4 \times T - 4$$

On host larvae (density-dependent survival on cattle)

Survival rate (S_L); depends on cattle type and tick density (ticks per host, D)

When tick density (tick exposure index) < 1000 , $S_L = 0.37$;

When $1000 \leq \text{tick density (tick exposure index)} < 15000$, $S_L = -0.000013 \cdot D + 0.382857$;

When $15000 \leq \text{tick density (tick exposure index)}$, $S_L = 0.19$

On host nymphs

Survival rate (S_N); depends on cattle type and tick density (ticks per host, D)

When tick density (tick exposure index) < 1000 , $S_N = 0.97$;

When $1000 \leq \text{tick density (tick exposure index)} < 15000$, $S_N = -0.000027 \cdot D + 0.997143$;

When $15000 \leq \text{tick density (tick exposure index)}$, $S_N = 0.59$

On host adults

Survival rate (S_F and S_M); depends on cattle type and tick density (ticks per host, D)

Male and female ticks are separated during the transition of nymphs to adults on host using a constant female/male ratio of 1.36:1.

Male ticks are contained in one accumulator with no age structure.

The time on host is 1 or 2 weeks for females (50% split).

When tick density (tick exposure index) < 1000 , $S_F = S_M = 0.79$;

When $1000 \leq \text{tick density (tick exposure index)} < 15000$, $S_F = S_M = -0.000023 \cdot D + 0.812857$;

When $15000 \leq \text{tick density (tick exposure index)}$, $S_F = S_M = 0.47$

Engorged adult females

Base survival rates (S_{EF} , under optimal weather conditions) in three different types of pasture

CDW (cumulative degree-weeks) ≥ 30

DT (minimum developmental threshold temperature) = 15

$$1-4 \text{ weeks old, } S_{EF1} = \begin{cases} 0.974004 & (\text{improved dense pasture}) \\ 0.945742 & (\text{unimproved light pasture}) \\ 0.897901 & (\text{improved light}) \end{cases}$$

$$> 4 \text{ weeks old, } S_{EF2} = \begin{cases} 0.8428791 & (\text{improved dense pasture}) \\ 0.8096603 & (\text{unimproved light pasture}) \\ 0.7221155 & (\text{improved light}) \end{cases}$$

Survival rate effects (SRE) for the temperature (T), saturation deficit (SD), and precipitation index (PI)

$$1-4 \text{ weeks old, } SRE_{young} = (-0.00097222 \cdot T^2 + 0.03111111 \cdot T + 0.75111111) \times (-0.00123643 \cdot SD^2 + 0.01456543 \cdot SD + 0.95708835) \times (-0.00060557 \cdot PI^2 + 0.0159513 \cdot PI + 0.89479707)$$

$$> 4 \text{ weeks old, } SRE_{old} = (-0.00114583 \cdot T^2 + 0.036250 \cdot T + 0.71333333) \times (-0.00141020 \cdot SD^2 + 0.01827455 \cdot SD + 0.94021589) \times (-0.00074267 \cdot PI^2 + 0.0194957 \cdot PI + 0.87183511)$$

References

1. Mount GA, Haile DG, Davey RB, Cooksey LM. Computer simulation of *Boophilus* cattle tick (Acari: Ixodidae) population dynamics. Journal of Medical Entomology. 1991;28 2:223-40; doi: 10.1093/jmedent/28.2.223. <https://doi.org/10.1093/jmedent/28.2.223>.
2. Cooksey LM, Davey RB, Ahrens EH, George JE. Suitability of white-tailed deer as hosts for cattle fever ticks (Acari: Ixodidae). Journal of Medical Entomology. 1989;26 3:155-8.